The relationship between anticipatory and compensatory components of human balance control
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Introduction

- A variety of daily situations (such as lifting loads, being hit while walking) create dynamic forces which shift the body’s center of mass (COM) closer to or outside the base of support, thereby perturbing body balance.
- The central nervous system (CNS) uses two principal control mechanisms to counteract such disturbances and maintain balance:
  - Anticipatory postural adjustments (APAs)
  - Compensatory postural adjustments (CPAs)
- APAs are changes that occur in muscle activity levels prior to a forthcoming perturbation.
- CPAs serve as mechanism of restoration of balance after a perturbation has already occurred.
- While the individual roles of these two components have been studied, an interaction between the two remains to be understood.

Research Aim

To determine the role of APAs in subsequent control of posture, specifically, its relationship with CPAs in controlling body balance.

Methods

- Eight healthy young adults, 4 males and 4 females (mean age ±2 years).
- While standing, subjects were exposed to external predictable (eyes open, APAs available) and unpredictable (eyes closed, no APAs) perturbations of identical magnitudes applied at the shoulder level (Fig. 1).
- A signal from the accelerometer attached to the pendulum was used to record the moment of body perturbation ($T_0$).
- Integrals of EMG activity ($\text{Int}_{EMG}$) of trunk and leg muscles, joint angles, COM and center of pressure (COP) displacements during both conditions were calculated for four different epochs (APA1, APA2, CPA1, and CPA2), each of 150 ms duration in relation to $T_0$.
- Repeated measures ANOVAs followed by post hoc analysis were performed, significance was set at $p < 0.05$.

Results

- Strong APAs and significantly smaller CPAs were seen in all muscles during predictable perturbations as opposed to unpredictable perturbations which were associated with an absence of APAs and significantly larger CPAs (5 times greater, $p < 0.01$) (Fig. 2).
- With the utilization of APAs, COM displacement after the perturbation peaked to 17 ± 5.5 mm and COP displacement peaked to 28 ± 3.6 mm, while in the absence of APAs, COM peak displacement was 1.6 times larger reaching 28 ± 9.6 mm and COP peak displacement was twice greater reaching 60 ± 14 mm, (all $p < 0.01$) (Fig. 3 and 5).
- Interestingly, the times at which each of the COM and COP variables reached their peak displacements were consistently similar between conditions, thus independent of the availability of APAs (Fig. 4).

Discussion

- The CNS assesses the availability of APAs and generates or scales down CPAs accordingly.
- Such utilization of APAs results in smaller COM-COP displacements after a perturbation, thereby enhancing body stability.

Conclusion

- The outcome of this study illustrates the interplay between anticipatory and compensatory mechanisms of balance control and highlights the role of APAs in maintaining balance.
- It also suggests the importance of optimizing the utilization of APAs in rehabilitation of individuals with balance impairments.

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References: